The University of Chicago

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A DISSERTATION SUBMITTED TO THE FACULTY
OF THE DIVISION OF THE BIOLOGICAL SCIENCES
IN CANDIDACY FOR THE DEGREE OF DOCTOR
OF PHILOSOPHY

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THE EFFECT OF MALE HORMONE ON AGGRESSIVE BEHAVIOR IN MICE[1]

ELIZABETH A. BEEMAN

MALE mice are extremely combative and, when caged together, usually establish social hierarchies based on dominance-subordination relationships. Evidence that aggressive behavior among such groups of mice may be very pronounced is found in the fact that deaths from active fighting have been frequently reported (Crew and Mirskaia, 1931; Greenwood *et al.*, 1936; Retzlaff, 1938).

Seven types of social orders have been described by Uhrich (1938) for laboratory groups of five albino mice; six of these are based on fighting. If the social orders representing varying degrees of stability are combined and if one in which no fighting occurs is eliminated, two main types result: a pyramidal order, and the type most frequently found, in which there is exclusive dominance by one mouse and no fighting or resistance

[1] I wish to express my deep appreciation to Dr. W. C. Allee for constructive criticism and interest given during the course of this investigation, and to the Jackson Memorial Laboratory and Dr. J. P. Scott, director of behavior studies, for animals, research facilities, and help extended to me during the summer of 1946. I also wish to thank Dr. Sewall Wright for critical aid with statistics.

by the four subordinates. These social orders range in permanence from 1 or 2 days to several months.

Several factors have been shown to be of importance in determining social dominance in mice. Uhrich (1940) suggests that if the difference between the body weight of two mice is greater than 5 gm. (15–20 per cent of total weight), the heavier mouse will tend to win encounters. Fatigue, illness, and severe injuries reduce aggressiveness in most mice (Ginsburg and Allee, 1942). Under the experimental conditions used by these authors, starvation for 12, 24, or 36 hours did not induce changes in aggressive behavior; and, after 6–8 hours' deprivation of water, access to a single water bottle with a small nozzle which permitted only one mouse to drink at a time did not stimulate fighting. Among the mice used by Uhrich (1940), relative age appears to have been of no importance in the winning of encounters, provided that the weight differences were not too great.

It has been demonstrated by Ginsburg and Allee (1942) that previous experience is a very important factor in determining social dominance. They have shown that, as a result of numerous defeats, mice may be conditioned to be less aggressive and can also be made more aggressive by a series of victories over submissive mice. Conditioning of either type affects the ability of a mouse to secure or to maintain high social status. Among mice, previous experience in winning encounters is apparently a factor of greater importance in maintaining social dominance than is physical well-being. Beeman and Allee (1945) report that C57 black mice in extreme stages of vitamin B_1 avitaminosis will maintain high social rank despite physical weakness sufficient for almost complete impairment of active aggressiveness.

Scott (1940, 1942), in studies of prefighting behavior in mice, described differences in aggressiveness between genetically distinct strains of mice at the Jackson Memorial Laboratory. In addition to the hereditary differences in prefighting behavior described by Scott, Ginsburg and Allee (1942) have demonstrated differences in aggressiveness, including fighting ability, for the C57 black, C3H, and Bagg albino strains of mice. Mice of these strains have been inbred for many generations, and each strain is almost completely homozygotic. After observing many battles, Ginsburg and Allee were able to establish relatively stable hierarchies, which varied in the middle ranks and were most stable at the extremes.

The data reported by Scott (1942) and by Ginsburg and Allee (1942) are primarily concerned with the ability of mice to begin or to win interstrain or intrastrain encounters. The normal aggressive behavior of mice (see p. 378) has not been described in terms of the frequency with which various components of the aggressive pattern occur within a given strain or in terms of the relative aggressiveness within strains.

Although numerous studies have demonstrated the importance of male hormone in stimulating aggressive behavior among vertebrates in general, there is little direct evidence concerning the effect of androgens on aggression in rodents. Seward (1945*a*) reports unpublished data by Riege, who found that after castration three male rats were reduced to the level of the controls, although they had previously scored reliably above the others in aggressiveness. Treatment with testosterone propionate significantly raised their aggressiveness. Seward states (p. 194) that ". . . . it appears likely that androgenic hormone

plays a definite part in activating aggressive behavior in male rats."

Beach (1945) castrated a male rat that was "an unusually vigorous copulator when placed with females in heat." Masculine copulatory responses were not significantly altered when first tested, 6 days after castration. The second test, conducted 5 days later, showed loss of both copulatory behavior and aggressiveness. Injections of testosterone propionate restored copulation, including the power of ejaculation, and revived aggressiveness.

The only study which bears directly on this problem in mice is that by Uhrich (1938), in which it was shown that castration of albino mice results in a considerable diminution of the fighting reaction of some males, but it does not completely inhibit the reaction in all individuals.

The present study was undertaken in an attempt to describe more fully, and in quantitative terms, the normal aggressive behavior of male C57 black and Bagg albino mice and to investigate further the role played by androgens in such behavior.

ANIMALS AND THEIR TREATMENT

All the mice used in this investigation were C57 black or Bagg albino males obtained from the stocks of mice at the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, or from a mouse colony maintained at Whitman Laboratory, University of Chicago. The animals in the latter colony are descended from mice originally obtained from the inbred stocks at the Jackson Laboratory and are members of the stocks used by Ginsburg and Allee (1942) and by Beeman and Allee (1945).

Experiments were designed to yield additional information of the characteristics of normal aggressive behavior of C57 black and Bagg albino male mice in intrastrain encounters and, in addition, to investigate the role which male hormone plays in determining aggressive behavior. The mice used included thirty-seven C57 black mice (ten experimental sets), and thirty-one Bagg albino mice (eight experimental sets). The experiments on these sixty-eight mice, which will henceforth be referred to as "B" mice, were performed at the Jackson Laboratory and were primarily concerned with the relation of male hormone to aggressive behavior. Additional experiments were run on six sets of four normal C57 black mice and three sets of four normal Bagg albino mice. These mice, designated as "W" mice, were used in experiments carried out at Whitman Laboratory in Chicago.

B MICE

At Chicago, the mice were bred and isolated in sheet-metal cages that measured $7 \times 7\frac{1}{4} \times 12$ inches. At the Jackson Laboratory each mouse was isolated in a wooden box which measured $11\frac{1}{2} \times 5\frac{1}{4} \times 6$ inches and which had a wire-mesh cover with a food hopper, so that Fox Chow Checkers were constantly available to the mice, in addition to water. Shavings were placed in the wooden cages in which the mice remained isolated except during the staged encounters. They were transferred to clean boxes every 2 weeks by picking up by the tail by hand, were handled only by the author and only at this time. Eleven mice of each strain were shipped from the colony at Chicago to Bar Harbor in a special box, which kept each mouse isolated from every other mouse. Judged by their subsequent behavior, the shipping did not affect their aggressiveness.

Age at initial isolation in the eight sets of albino and ten sets of C57 black mice varied from 21 to 64 days of age. All the

mice in one set were isolated at the same time and were littermates or from litters born a few days apart. Each mouse was earmarked for purposes of identification.

Following the procedures used by Ginsburg and Allee (1942) and Beeman and Allee (1945), round-robins of encounters were staged, in which each mouse met every other mouse in the experimental group. Thus in a group of four mice there were six encounters per round. During a week, the mice in each experimental group met in one complete round-robin on each of 2 days. The order of encounters was varied, so that individuals did not meet in the same sequence in consecutive rounds. The animals which were brought together in round-robin encounters were considered members of the same "group" or "set" of mice, regardless of the fact that during the greater part of the time they were not caged together.

Encounters were staged in a neutral wire cage (mesh $\frac{5}{16}$ inch). This cage, which had a removable sheet-metal bottom, measured $9\frac{1}{2} \times 9\frac{1}{2} \times 12$ inches and was divided into two equal sections by a galvanized-iron partition that could be readily raised. In order to transfer a mouse from his home cage to the "fighting cage," a piece of wire screen was placed in the home cage; after the mouse had climbed onto the screen, it was transferred to the neutral cage, where it remained until the mouse had climbed off. The same procedure was used to return a mouse to his home cage.

During an encounter all room lights were turned off, and a lamp with a 60-watt bulb was placed over the cage. Encounters were begun by raising the partition between the two mice and were permitted to continue until one of the two had won the encounter or, if no decision was reached, until 5 minutes had elapsed. An encounter is considered won when one mouse actively submits to another or squeaks and runs away.

Six sets of castrate albino mice and seven sets of castrate C57 black male mice were each allowed to experience at least six rounds of encounters. Of the twenty-three albino mice castrated, one set of three mice was deprived of its gonads at 27 days of age, and five groups of four mice were castrated at 29, 44, 77, 80, and 83 days of age, respectively. Age at isolation varied from 21 to 54 days after birth in the six groups.

Twenty-five C57 black mice were divided into four groups of four mice each, which were castrated at 23, 54, 74, and 83 days, and three groups of three mice, which were castrated at 27, 62, and 90 days of age. Age at isolation varied from 23 to 61 days after birth. The first staged encounters among the thirteen sets of castrates occurred from 25 to 140 days after castration.

A control operation duplicating castration procedures was performed on one set of four black mice and one set of four albino mice. In this operation the mouse was anesthetized, the abdomen was opened, and the gonads were pulled out through the incision and returned to the abdominal cavity. The animal was then sewed up. One normal group of four albino mice and two normal groups of four black mice were used as additional controls.

After six rounds of encounters had occurred, pellets of testosterone propionate[2] were implanted subcutaneously in three of the six sets of castrate albino mice and in four of the seven sets of castrate C57 black mice. The average weight of the eleven testosterone pellets implanted in the albino mice was 15.1

[2] The pellets of testosterone propionate were made available through the courtesy of Dr. Erwin Schwenk of the Schering Corporation.

mg. (range 14.5–15.6). The fourteen pellets placed under the skin of the C57 castrates averaged 15.5 mg.; they ranged in weight from 15 to 16.2 mg. The disk-shaped pellets, which were weighed to 0.1 mg. on an analytical balance, had a diameter of 4 mm. and a thickness of 1.25 mm.; the average surface area was 40.8 sq. mm.

Six pellets were recovered, upon which rates of absorption of the testosterone propionate could be approximated. The method of calculation consisted of dividing the total amount of hormone absorbed by the number of days during which the pellets were implanted. For these pellets the rate was found to be 0.15 mg. per day. Kochakian (1941) states that the amount of hormone absorbed is in relation to the surface area of the pellet and not to the mass. He implanted mice with pellets of testosterone propionate of two sizes, 21.8–24.1 mg., average surface area 44.8 sq. mm., and 9.8–12.6 mg., average surface area 27.3 sq. mm. From his data we can calculate that the absorption rate for eight of the larger pellets was 0.183 mg. per day and for three of the smaller pellets, 0.123 mg. per day. These figures are in line with those reported here, since the pellets used to compute absorption rates ranged in weight from 15 to 16 mg. and had a surface area of approximately 41 sq. mm.

In order to implant the pellets, the mice were etherized, most of the hair was removed from an area over the right shoulder, and, after the region had been moistened with alcohol, a cut was made through the skin. A pocket in which to place the pellet was opened out, with the aid of forceps, between the skin and the underlying muscles. After the pellet had been inserted, the incision was sewed up. The pellets were allowed to remain under the skin until six additional rounds of encounters had been completed by the seven sets of castrate mice during a period of 3 weeks.

The implanted pellets caused local damage to the tissues and made the overlying skin very soft. During the fights which began soon after the pellets were introduced, the skin in this area was frequently torn, and the pellets protruded from the wound. In such cases the mice were again anesthetized, the pellets returned to the pocket, and the skin sewed. In instances in which the pellet was lost after the skin had been torn, a second pellet was introduced. A few pellets were placed beneath the skin in the region of the right hip. However, this site was as exposed to injury during an attack as the right shoulder, and the pellets did not always remain under the skin in this area.

After the second six rounds of encounters, the mice were again anesthetized, and the pellets were removed, washed in distilled water, and, after being dried, were weighed. Two sets of C57 black mice and one set of albino mice from which the pellets had been removed experienced a third group of six additional rounds of encounters—a total of eighteen rounds per set. Only mice in which the fate of all implanted pellets was known were allowed to continue in this third group of six rounds of encounters. If, at the end of the second group of six rounds, a pellet could not be recovered, that particular mouse was excluded from further encounters.

In addition, two sets of castrate albino mice and two sets of C57 black mice received subcutaneous implants of pellets of dextrose after the first six rounds. These pellets were of approximately the same size as those of testosterone propionate and were similarly implanted. The average weight of the eight dextrose pellets implanted in the albino mice was 13.2 mg. (range 10.5–17.8), and that of

seven pellets given to C57 castrates was 14.7 mg. (range 12–19.2 mg.).

W MICE

In Chicago the mice were kept in a dark room in Whitman Laboratory. The ceiling lights were on for various lengths of time during the day, and the temperature was fairly constant, approximately 23° C. during the winter months and 25° C. during the summer. The temperature infrequently varied between 20° and 30° C., with no observable effect on the aggressiveness of the mice.

Breeding and isolation of the mice occurred in screen and sheet-metal cages whose measurements were $7 \times 7\frac{1}{4} \times 12$ inches. The mice were transferred to larger wire-meshed cages, $9\frac{1}{2} \times 9\frac{1}{2} \times 7$ inches, a few days before staged encounters were to begin and remained isolated in these cages except during the encounters.

The cage and experimental procedures used for staging encounters were identical with those already described for the B mice. In all instances two round-robins were completed each week. However, in some sets, all the encounters of one round-robin were not run on one day. Consequently, any given mouse in these sets experienced fewer encounters per day than did the other mice, although the total number during a single week was the same in both cases.

All the mice were isolated as soon after 21 days of age as cage space was available. Average age at isolation of five groups of black mice and three groups of albinos was 28.5 days.

RESULTS

BEHAVIOR OF NORMAL MICE IN INTRA-STRAIN ENCOUNTERS

The normal aggressive behavior pattern of adult, male, C57 black and Bagg albino mice may include hair-fluffing, tail-rattling, mincing, parrying, attacking, chasing, and fighting. All these terms except parrying are defined by Ginsburg and Allee (1942) or by Beeman and Allee (1945). For example, while mincing, a mouse rapidly takes many small steps near or in circles around another mouse. While parrying, mice balance on their hind legs and strike at each other with their forelegs. In addition to the behavior mentioned, normal adult males, when caged together, may spend time in grooming or sniffing each other, independently investigating the cage, actively submitting, squeaking, and running away. Because, in many cases, it was impossible to distinguish between grooming and sniffing, such activities have been combined and classified as "grooming."

After the control operation, mice of both strains behaved very much like normal animals. Since some groups of mice experienced more rounds of encounters than other groups and a comparison of total amounts of activity exhibited would not be meaningful, it was necessary to compute the average activity per group per round in order to make comparisons of the behavior of the operated and the unoperated mice. Except for one instance in which the operated-normal albino mice gave 23 more tail rattles than the largest number given in any one round by normal albino mice, the activity of the operated controls of both strains was within the general range of variability of the various sets of normal controls. In both strains the greatest number of attacks or fights during a single round occurred in normal sets. An analysis of the behavior of one group of normal albino mice and that of one group of operated-normal mice of this strain is given in the first two horizontal columns in Table 1. It is evident that the aggressive behavior of the operated mice was not significantly depressed. Actually,

when comparisons are made on the activity observed in the same number of rounds, the operated albino mice exhibited, on the average, more tail-rattling, mincing, attacking, and fighting per round than did the normal albino mice. The difference between the amount of attacking, parrying, and fighting displayed by normal and operated-normal mice is very slight.

In the third and fourth horizontal columns of Table 1 it can be seen that during six rounds of encounters the normal C57 black mice displayed practically the same amount of tail-rattling, parrying, and attacking per group per round as did the operated animals of this strain. On the other hand, the latter group more frequently engaged in mincing and fighting. Consequently, since the control operation had no observable depressing effect on the behavior of either the C57 black or Bagg albino mice and since the activity of the control-operated mice was within the range of variability of the normal controls, data from normal and operated-normal mice have been combined, and no further distinctions will be made between the behavior of these two groups.

The various components of the aggressive behavior pattern may not be exhibited in maximum amount during the first few encounters, and in later encounters fluctuations in the frequency with which these behavior signs occur is evident. In two groups, each of which was composed of four normal males, black Sets VI and VII, the only activity exhibited during the first round of encounters was grooming or sniffing and independent activity. In a similar group —black Set III—the only aggressive behavior in the first round of encounters was one tail rattle. During the second round of encounters all types of aggressive behavior were present in black Sets III and VII and continued to appear, with fluctuations in frequency, until the end of the 18th and 16th rounds, respectively, when the encounters were discontinued. The four mice of black Set VI were a little slower in beginning to act aggressively. Only 2 attacks and 1 parry were made in the second round, but in the third round the complete ag-

TABLE 1

COMPARISON OF THE BEHAVIOR OF NORMAL MICE WITH THAT OF NORMAL ANIMALS UPON WHICH A CONTROL OPERATION HAS BEEN PERFORMED (B MICE)

Mice		Total No. Rounds per Group	Total No. Encounters per Group	Average Activity per Group per Round				
				Tail Rattle	Parry	Mince	Attack	Fight
Bagg albino	1 group of 4 normals	12	72	26.5	0.085	1.6	14.2	8.5
	1 group of 4 operated normals	12	72	32.5	0.083	4.7	15.4	8.8
C57 black	Average of 2 groups of 4 normals	6	36	4.6	1.8	1.8	24.4	15.6
	1 group of 4 operated normals	6	36	4.5	2.0	8.1	24.3	21.5

gressive pattern appeared. All three groups were similar in showing some aggressive activity in the second round of encounters and in continuing to act aggressively until the termination of the experiments.

In all graphs in this report, a scale of activity has been adopted in which the occurrence of 1 tail rattle, attack, fight, or other behavior sign has arbitrarily been made equal in value. Thus comparisons of the relative frequency with which various behavior signs occur may be made.

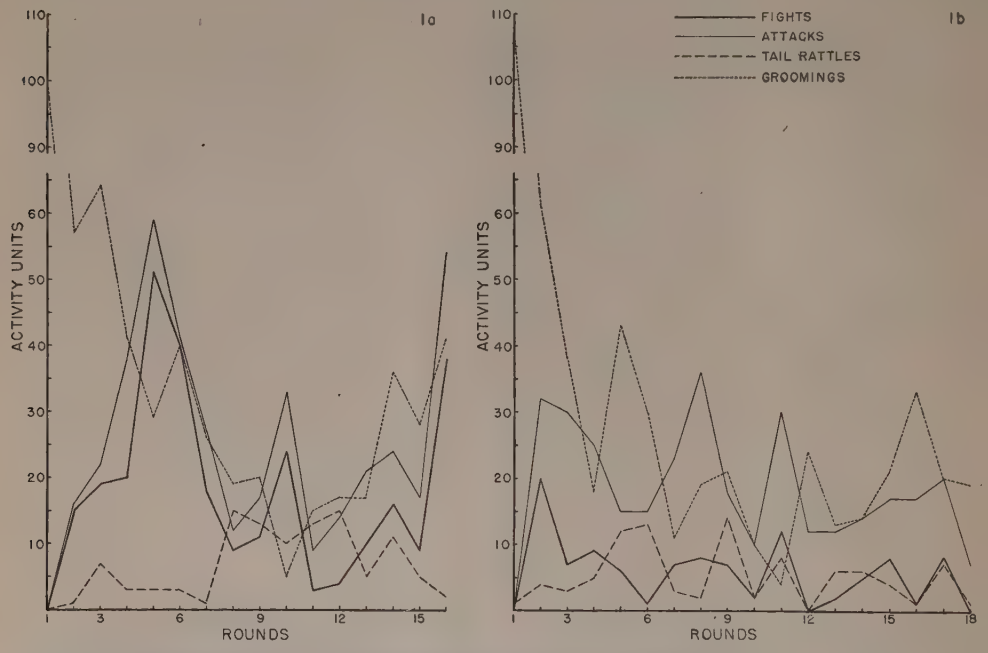

FIG. 1.—Average aggressive activity of normal C57 black male mice in groups of four. *a*, Set VII; *b*, Set III. Note that activity units between 66 and 89 are omitted.

Figure 1 indicates the amounts of grooming, tail-rattling, attacking, and fighting which occurred during several rounds of encounters in two groups of normal C57 black mice. These graphs clearly show the fluctuations that may normally appear in the number of times that a given bit of aggressive behavior may be given in a succession of rounds of encounters. They also show that the increases and decreases in amount of a given aggressive act do not occur at the same time in different groups of mice. Attacking and fighting began during the second round of black Set VII (Fig. 1, *a*), and the first major rise in frequency of attacking and fighting took place in the fifth round of encounters engaged in by this group of mice. The mice of black Set III (Fig. 1, *b*), which were normal animals, similarly treated, also began attacking and fighting in the second round but exhibited these behavior signs more times than did the mice of black Set VII during this round. However, in Set III, the amount of such aggression decreased from the original high value until, by the fifth round, 15 attacks and 6 fights were displayed, as compared with 59 attacks and 51 fights, which occurred during the fifth round of Set VII.

The behavior of two groups of normal

albino mice—Sets V and IX (Fig. 2)—was qualitatively similar to that of the normal C57 black mice with regard to the time of first appearance of components of the aggressive behavior pattern and of occurrence of fluctuations in amounts of these components. As in the blacks, the encounters during the first round were low in aggressive behavior; no aggression of any sort appeared in one group, and only 3 tail rattles were shows that, although the normal mice of Set V were the first to show signs of aggressiveness by displaying 3 tail rattles in the first round, as compared with no aggressive activity on the part of the control-operated mice, the latter group—Set IX—exhibited far more aggressive behavior during the first six rounds than did the unoperated group. During these six rounds the control-operated mice gave 215 tail rattles and engaged in 100

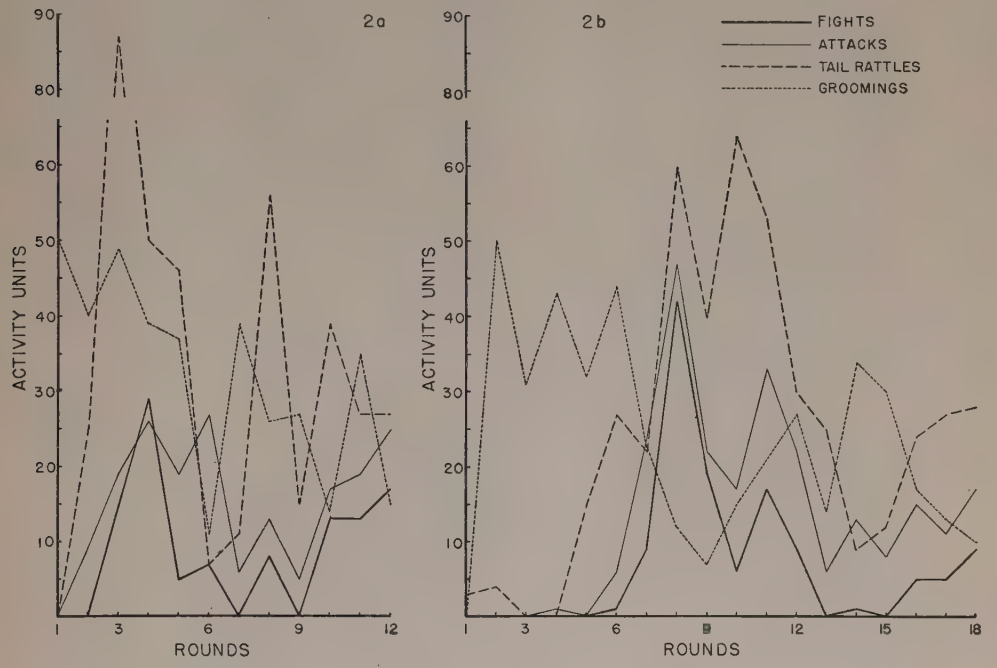

FIG. 2.—Average aggressive activity of normal Bagg albino male mice in groups of four. *a*, Set IX (operated normals); *b*, Set V. Note that activity units between 66 and 79 are omitted.

exhibited by the other. In the second round, however, Set IX displayed 25 tail rattles and 9 attacks. By the third round the aggressive activity of this group had increased to 87 tail rattles, 6 minces, 19 attacks, and 15 fights.

It has previously been indicated that the control operation did not quantitatively depress aggressive behavior and that the operated groups were, indeed, on the average, slightly more aggressive than unoperated groups of mice. Figure 2 attacks and 56 fights, in contrast with 49 tail rattles, 7 attacks, and 1 fight performed by the normal mice in six similar rounds of encounters.

COMPARISON OF THE BEHAVIOR OF NORMAL BLACK MICE WITH THAT OF NORMAL ALBINO MICE

Although the aggressive behavior of the C57 black mice appears to be qualitatively like that of the albino mice, in some respects it is not quantitatively

similar, since there are differences in the frequency with which normal males of these two strains of mice display various signs of aggressive behavior.

The average amount of attacking and tail-rattling per group per round for three groups of normal B C57 black and two groups of normal B albino mice is shown in Figure 3. It is evident that large fluctuations in the amount of tail-rattling

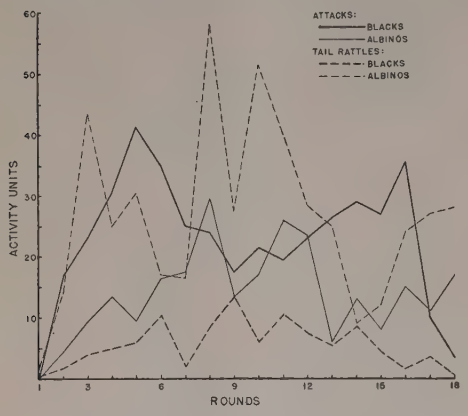

FIG. 3.—Comparison of the average activity per group per round in groups of four normal C57 black and Bagg albino male mice. C57 black Sets III, VI, VII; Bagg albino Sets V, IX.

and attacking do occur. However, in each of eighteen rounds, the average amount of tail-rattling displayed by the groups of albino mice was greater than that shown by the black mice. On the other hand, the albinos exceeded the blacks in the amount of attacking in only five of seventeen rounds. The general trend is for the blacks to exhibit more fighting per round. For example, during eighteen rounds the black mice displayed an average of 11.4 fights per group per round, as compared with an average of 6.3 fights per group per round on the part of the albinos (Table 2). In twelve of the eighteen rounds, the blacks displayed more fighting and exceeded the albinos by an average of 10.9 fights per round. During the five remaining rounds the albinos displayed an average of 8 more fights than did the blacks.

If the aggressive activity of comparable castrated mice of both strains is compared after implantation of testosterone propionate, the albino mice are again much more active in displaying tail-rattling, and, in five out of six rounds, the blacks minced, attacked, and fought more than did the albinos. Figure 4 lists the average number of attacks and fights exhibited per group per round during the first five rounds experienced by five sets of W C57 black and three sets of W albino mice. Again there is wide variation within strains. However, the average number of fights per group per round is 17.2 among the C57 blacks and 2.1 among the albino mice. The average number of attacks per group per round among the C57 mice was 16.5, as compared with an average of 2.8 attacks per round among the albino mice.

During the first six rounds of encounters, nine groups of normal C57 blacks and two groups of castrate C57 blacks implanted with male hormone performed more attacks, fights, and minces per group per round than did four normal groups of albinos and two groups of implanted albino castrates. The latter displayed more tail rattles per group per round than did the former (Table 2).

There is a tendency for the mice to be relatively unaggressive during the first rounds of encounters, to be increasingly aggressive during later encounters, and, finally, after meeting in numerous encounters, to show decreased aggression. In later encounters the mice tend to submit rather than to fight when attacked; and, since encounters were terminated after a submission was given, the amount of aggression exhibited was usually less than that found in many earlier rounds. In addition to variability in performance from round to round within a given group

of mice, the variability between groups of mice of one strain is such that, with the data from the available groups of mice, the difference in any behavior trait between strains is not statistically significant. However, in the first six rounds of encounters, each of eleven groups of C57 black mice displayed more attacks than tail rattles, and each of six groups of albino mice displayed more tail rattles than attacks. When the ratio

$$\frac{\text{Attacks}}{\text{Tail rattles}+\text{attacks}}$$

in both strains is compared, the difference between the two strains is highly significant: $P < 0.0001$ $(t = 11+)$.[3]

[3] The population formula of Fisher was used. Degrees of freedom are $n_1 + n_2 - 2$.

$$t = \frac{\bar{v}_1 - \bar{v}_2}{\sqrt{\left(\frac{(\Sigma v_1^2 - \bar{v}_1 \Sigma v_1) + (\Sigma v_2^2 - \bar{v}_2 \Sigma v_2)}{n_1 + n_2 - 2}\right) \times \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}.$$

EFFECTS OF CASTRATION ON THE AGGRESSIVE BEHAVIOR OF MALE MICE

Practically no aggression was shown in the 198 encounters engaged in by the twenty-three castrate albino mice which were members of six sets (Table 3). The sole castrate of this strain to display any aggressive behavior rattled his tail twice

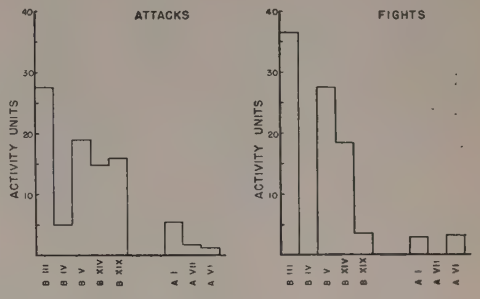

FIG. 4.—Average aggressive activity per group per round in groups of four C57 black and Bagg albino male mice, based on data for the first five rounds of encounters for each group of W mice. *B* represents C57 black males; *A* represents Bagg albino males. Roman numerals indicate groups of four mice.

TABLE 2

DIFFERENCE BETWEEN THE AMOUNT OF AGGRESSIVE ACTIVITY PER GROUP PER ROUND OF C57 BLACK AND BAGG ALBINO MICE

		Attack	Fight	Mince	Tail Rattle
	Normal Groups of 4 Mice (Rounds 1–18)				
B mice.....	3 groups of C57 blacks	20.4	11.4	4.6	5.5
	2 groups of albinos	13.9	6.3	3.6	26.6
	Castrate Groups of 4 Mice with Pellets of Testosterone Propionate (Rounds 7–12)				
B mice.....	2 groups of C57 blacks	25.6	18.0	10.3	12.4
	2 groups of albinos	16.3	10.8	3.8	37.8
	Groups of 4 Mice, Normal, or Castrate with Pellets of Testosterone Propionate (Rounds 1–6)				
B and W mice..	11 groups of C57 blacks	19.8	11.9	3.5	5.1
	6 groups of albinos	9.3	5.7	2.4	22.2

TABLE 3

AGGRESSIVE BEHAVIOR OF MICE: NORMALS, CASTRATES, AND CASTRATES IMPLANTED WITH TESTOSTERONE PROPIONATE OR DEXTROSE PELLETS

Strain	Set	No. Mice per Set	Activity in First 6 Rounds of Encounters					Treatment	Activity in Second 6 Rounds of Encounters					Treatment	Activity in Third 6 Rounds of Encounters				
			Tail Rattle	Parry	Mince	Attack	Fight		Tail Rattle	Parry	Mince	Attack	Fight		Tail Rattle	Parry	Mince	Attack	Fight
Albino ♂	I	3	0	0	0	0	0	T.P.*	138	1	26	79	58						
Albino ♂	II	4	0	0	0	0	0	T.P.	267	1	24	117	104	T.P. out	1	0	1	0	0
Albino ♂	VI	4	2	0	0	0	0	T.P.	187	0	23	79	26						
Albino ♂	III	4	0	0	0	0	0	Dextrose	0	0	0	0	0		0	0	0	0	0
Albino ♂	VIII	4	0	0	0	0	0	Dextrose	0	0	0	0	0						
Albino ♂	VII	4	0	0	0	0	0												
Normal ♂	V	4	49	0	1	7	1		269	1	18	169	102		125	0	28	70	20
Normal ♂ operated	IX	4	215	0	23	100	56		175	1	34	85	51						
C57 black ♂	II	3	2	0	0	0	0	T.P.	27	8	29	48	18	T.P. out	3	0	0	3	0
C57 black ♂	IX	3	0	0	0	0	0	T.P.	1	0	15	35	0						
C57 black ♂	I	4	0	0	0	0	0	T.P.	59	13	86	150	87	T.P. out	22	0	26	47	0†
C57 black ♂	V	4	0	0	0	0	0	T.P.	90	14	38	158	129						
C57 black ♂	IV	3	0	0	0	0	0	Dextrose	0	0	0	0	0						
C57 black ♂	VIII	4	0	0	0	0	0	Dextrose	0	0	0	0	0						
C57 black ♂	XI	4	0	0	0	0	0												
Normal ♂	III	4	38	8	11	117	43		29	9	37	129	36		25	7	30	87	24
Normal ♂	VII	4	17	13	11	176	145		67	6	38	112	69						
Normal ♂ operated	VI	4	27	12	49	147	129												

* Testosterone propionate.

† All aggressive behavior in third six rounds was displayed by Mouse No. 2, whose androgen pellet was removed in three pieces.

in the 17th encounter, which occurred during the 6th round of Set VI. He was one of a group of four mice which had been castrated at 80 days and had given no indication of aggressiveness in the sixteen preceding encounters. The aggressive behavior of the twenty-five castrate C57 black mice (seven sets), in the same number of encounters, also consisted of only 2 tail rattles (Table 3). These were displayed during the first round of encounters engaged in by Set II, which had been castrated at 23 days. In the total of 396 encounters experienced by castrate mice of both strains, none of the forty-eight mice showed any other sign of aggressiveness.

It is obvious that the removal of the gonads from male Bagg albino and C57 black mice results in the failure of the castrated mice to act aggressively, when a period of 25 or more days intervenes between castration and initial encounters. This is true if the mice are castrated as immature males or if castration occurs after 60 days of age, when they are sexually mature. In addition, the age at which they were previously isolated apparently has no effect on their behavior, and the number of encounters experienced does not appear to be of importance in inducing aggressive behavior in castrate mice, since the thirteen sets of castrate mice were, in all cases, permitted to meet in a minimum of six rounds of encounters; four sets experienced twelve rounds; and one set was run for eighteen rounds. It has been stated that male mice of both strains normally exhibit large amounts of various types of aggressive behavior at least by the second round of encounters.

This paucity of aggressive activity on the part of the castrate mice is especially striking when compared with the behavior of normal animals (Table 3). In 180 encounters the aggressive activity of eight normal albino mice (two sets) included 833 tail rattles, 2 parries, 104 minces, 431 attacks, and 230 fights. Twelve normal C57 black mice (three sets), in 240 encounters, rattled their tails 226 times, exhibited 69 parries, 180 minces, 884 attacks, and 518 fights. Since the total number of encounters in which the groups of castrates and groups of normal mice engaged was not the same, these results have been compared in Table 4 in terms of the average activity exhibited per encounter.

TABLE 4

COMPARISON OF THE AVERAGE ACTIVITY PER ENCOUNTER IN GROUPS OF NORMAL AND CASTRATE C57 BLACK AND ALBINO MICE

GROUP	TOTAL NO. OF ENCOUNTERS	AVERAGE ACTIVITY PER ENCOUNTER				
		Tail Rattle	Parry	Mince	Attack	Fight
23 castrate albino mice (6 groups)..	198	0.010	0	0	0	0
25 castrate black mice (7 groups)..	198	0.010	0	0	0	0
8 normal albino mice (2 groups)..	180	4.6	0.011	0.57	2.3	1.2
12 normal black mice (3 groups)...	240	0.94	0.24	0.75	3.6	2.1

Castrate mice, as a group, displayed more grooming or sniffing than did the normal mice. As indicated in Table 5, the castrate albinos averaged 7.3 groomings per encounter, as contrasted with 4.47 per encounter displayed by normal albino males. The difference between the behavior of castrate and normal C57

blacks is even greater; 14.9 groomings were engaged in per encounter by the castrates, as compared with 5.48 per encounter by the normals.

Squeaking, submitting, and running away are signs of submissive behavior. It is not surprising that the normal mice of both strains displayed these acts more frequently in each encounter than did the castrates of the same strain, since the former were actively engaging in attacks and fights and mice normally submit when beaten. It is of interest that the castrate mice of both strains showed any squeaking, submitting, and running away from other mice in the absence of active aggressive behavior, especially since Ginsburg and Allee (1942) state: "Submissive responses to aggressiveness do not usually occur until after several defeats, and this is an indication that learning is an important factor in such submissions" (p. 501). The twenty-three castrate albino mice squeaked once, submitted once, and ran away three times in 198 encounters. In the same number of encounters, the C57 black castrates showed much more submissive behavior with 37 submissions, 6 squeaks, and 20 instances of flight.

TABLE 5

SUBMISSIVE BEHAVIOR AND GROOMING IN NORMAL AND CASTRATE C57 BLACK AND ALBINO MICE

GROUP	NO. OF ENCOUNTERS	AVERAGE ACTIVITY PER ENCOUNTER			
		Groom	Squeak	Submit	Run Away
6 sets albino ♂	198	7.3	0.005	0.005	0.015
7 sets C57 ♂	198	14.9	0.030	0.186	0.10
2 sets albino ♂	180	4.47	1.35	0.57	0.57
3 sets C57 ♂	240	5.48	1.3	0.72	1.0

EFFECTS OF CASTRATION ON BODY WEIGHT

In all cases the average weights of the groups of castrate mice were consistently less than those of groups of normal mice of comparable strain and age. The average body weights among the four groups of castrate albinos ranged from 4.2 to 6.9 gm. less than the average weights of two groups of normal albino mice of comparable ages. The average body weights of six groups of castrate C57 blacks ranged from 1.3 to 6.2 gm. less than the average weights of three groups of normal mice of the same strain and age.

IMPLANTATION OF PELLETS OF TESTOSTERONE PROPIONATE IN CASTRATE C57 BLACK MICE

A dramatic change occurred in the behavior of the members of four groups of castrate C57 black mice soon after the implantation of pellets of testosterone propionate. The pellets were introduced after each group had completed six rounds of encounters, and they were not removed until 3 weeks later, when six additional rounds of encounters had occurred.

The seventh round for Set I, a group of four mice, was run on the next day after the pellets were implanted. On this day, one of the mice started to attack another mouse but stopped before carrying the act to completion. During the 8th round, which occurred 4 days after the implantation of the pellets, this group displayed 5 tail rattles, 7 minces, 47 attacks, 5 parries, and 27 fights—behavior

never exhibited by any of the four groups of castrate black mice in six previous rounds (Fig. 5, *a*). Three of the four mice in the group continued to be extremely aggressive during the entire period of time that the pellets of androgen were present. In the 12th round (6th round after introduction of pellets) these mice gave 20 tail rattles, 17 minces, 16 attacks, and 7 fights. Mouse No. 4, however, failed to exhibit any sign of aggressiveness.

The mice were allowed to experience a third set of six rounds of encounters after the pellets had been removed. During rounds thirteen through eighteen, mice Nos. 1, 3, and 4 did not perform a single aggressive act. Mouse No. 2, however, continued to rattle his tail and to mince for four more rounds and to attack during all the last six rounds. There were no fights, since the other mice merely submitted and squeaked or ran away when No. 2 acted aggressively. The pellet of this mouse was removed in three pieces, and the weight of these pieces suggests that the entire pellet was not retrieved.

The 7th round of encounters for Set V occurred 4 days after implantation of testosterone propionate pellets. At this time these mice gave 6 minces, 18 attacks, 9 parries, and 10 fights. The change in behavior which developed in all four mice during the rounds when the pellets of androgen were present are illustrated in Figure 5, *b*. The graph indicates that, although the amount of aggressive activity exhibited in any one round varied from that displayed in subsequent rounds, the mice continued to show signs of aggressiveness during the entire second group of encounters, rounds seven through twelve. Figure 5, *b*, also shows the drop in grooming which occurred when aggressive activity increased and the rise in grooming which took place when the amount of aggressive activity decreased.

The members of a third group of C57 black castrates, Set II, experienced the 7th round of encounters 2 days after receiving male hormone in subcutaneously implanted pellets. No change occurred in the behavior of this group of three mice during this round. They continued to spend time in grooming and independent activity. During the 8th round, which was staged on the 6th day after implantation, the three mice gave a total of 2 tail rattles, 10 minces, 11 attacks, 2 parries, and 6 fights (Fig. 5, *c*). All the mice continued to be aggressive in the 9th, 10th, 11th, and 12th rounds. In the six rounds after the pellets had been removed, mice Nos. 2 and 3 failed to show any signs of aggressiveness. Mouse No. 1 made 3 attacks, 1 in the 13th round and 2 in the 17th round. He also gave 3 tail rattles, 1 in the 17th and 2 in the 18th round.

The behavior of a fourth group of castrate C57 mice—Set IX—differed from that described for the three other groups of castrate mice which received pellets of male hormone. Unlike the members of Sets I, II, and V, the mice in this group never fought. In addition, the frequency with which tail-rattling, mincing, and attacking appeared was lower than that found in the other three sets. No aggressive behavior signs were displayed during the first round after implantation of the pellets. However, some aggression by No. 107 appeared in each succeeding round until the experiment was terminated after the 12th round. Mouse No. 108 never displayed any aggressiveness, and No. 109 displayed only 1 attack during the 12th round. The pellets of Nos. 108 and 109 were not recovered at autopsy, and it is possible that they were lost soon after implantation. The weights of the seminal vesicles and prostate glands lend support to this hypothesis.

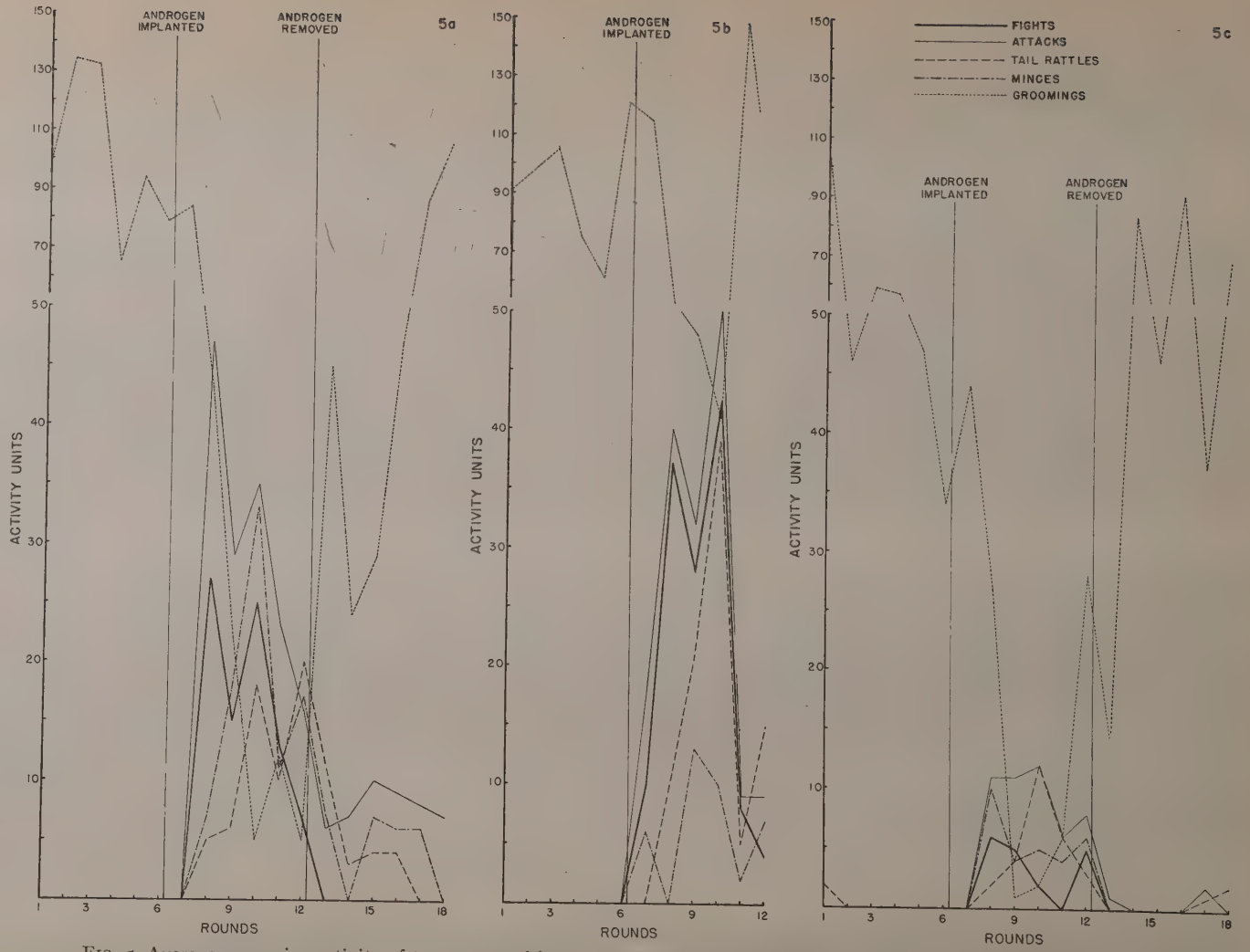

FIG. 5. Average aggressive activity of two groups of four and one group of three castrate C57 black male mice. Pellets of testosterone propionate present in rounds seven through twelve. *a*, Set I, group of 4 males. All aggressive behavior after round twelve was displayed by mouse No. 2, whose pellet was removed in three pieces (note that fighting ceases after round twelve). *b*, Set V, group of 4 males. *c*, Set II, group of 3 males. Note that the scale for activity units is reduced between 50 and 150.

In summary, twelve out of fourteen castrate C57 black mice which had received pellets of male hormone exhibited aggressive behavior. Aggressive activity was first displayed in encounters run on the 4th to the 6th day after implantation of androgen pellets, and the mice continued to show some signs of aggressiveness during subsequent encounters. Seven of these mice experienced encounters following the removal of the pellets, and only two of these showed any aggression.

IMPLANTATION OF PELLETS OF TESTOSTERONE PROPIONATE IN CASTRATE BAGG ALBINO MICE

After the castrate albino males of Sets I, II, and VI had completed six rounds of encounters, they received pellets of testosterone propionate. All were allowed to experience six additional rounds of encounters while implanted with male hormone, and the members of Set II were given a third set of six rounds after removal of the pellets.

In Set II the first round of encounters occurred 4 days after the pellets were implanted. All the mice in the group were actively aggressive at this time. During this round these previously unaggressive mice displayed 34 tail rattles, 2 minces, 28 attacks, and 29 fights. As indicated in Figure 6, *a*, the members of Set II continued to be aggressive throughout the six rounds of encounters which took place while the mice were carrying the pellets of androgen. Pellets were removed from three of the four mice of Set II after the 12th round. Since the pellet of No. 2 could not be found, only mice Nos. 1, 3, and 4 were permitted to continue in a third six rounds of encounters. Figure 6, *a*, clearly indicates that the aggressive behavior disappeared upon removal of the androgen pellets except for 1 tail rattle and 1 mince, which occurred in the first round after withdrawal of the hormone. As in the case of the C57 black mice, the amount of grooming and sniffing decreased when the aggressive behavior began and rose sharply in amount when the pellets of male hormone were removed.

The mice in albino Set VI (Fig. 6, *b*) first exhibited aggression in the 7th round, 4 days after having received pellets of testosterone propionate. Only two mice—Nos. 106 and 131—displayed signs of aggressiveness at this time. During the 8th round, mouse No. 129 also began to act aggressively, and it was not until the 9th round that the fourth member of Set VI—No. 130—showed the characteristic aggressive behavior pattern. Aggressive signs were displayed throughout the next three rounds until the end of the experiment.

The 7th round for members of Set I occurred 2 days after the pellets had been implanted, but no change in the behavior of the mice was seen. It was not until 4 days later, in the 8th round, that all the mice were actively aggressive (Fig. 6, *c*). This behavior continued in the 9th, 10th, 11th, and 12th rounds, with a total of 138 tail rattles, 1 parry, 26 minces,79 attacks, and 58 fights occurring before the encounters were ended at the close of the 12th round.

In summary, the eleven albinos, members of three castrate groups, received subcutaneous pellets of testosterone propionate, and all showed aggressive activity at sometime during the six rounds of encounters when male hormone was present. Table 3 includes the total amount of aggressive behavior displayed by the three groups of albino and four groups of C57 black castrates during the period in which they possessed pellets of testosterone propionate and in the periods preceding and following implantation.

It is interesting to compare the ac-

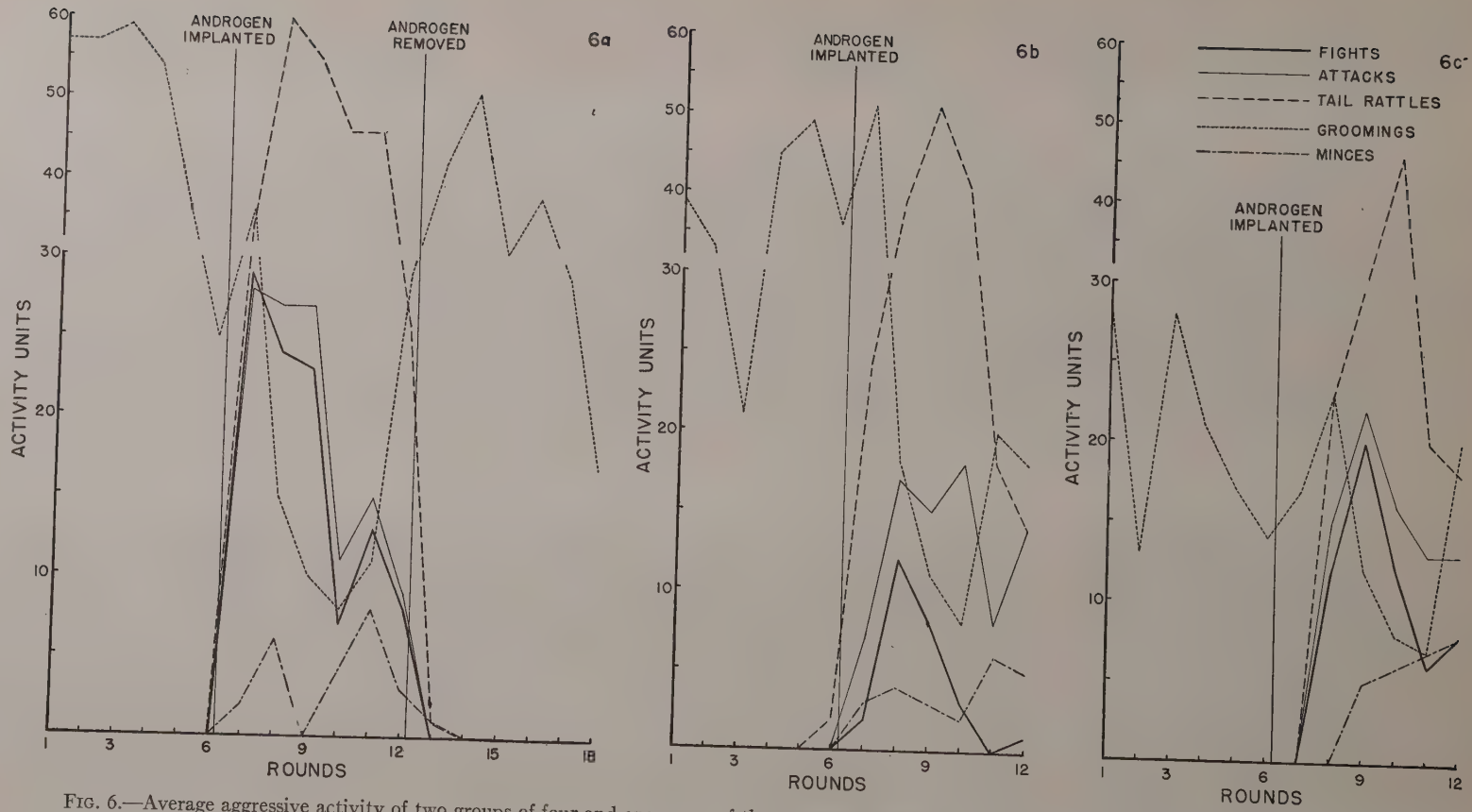

FIG. 6.—Average aggressive activity of two groups of four and one group of three castrate Bagg albino male mice. Pellets of testosterone propionate present in rounds seven through twelve. *a*, Set II, group of 4 males. Only three mice present in rounds thirteen to eighteen. *b*, Set VI, group of 4 males. *c*, Set I, group of 3 males. Note that the scale for activity units is reduced between 30 and 60.

tivity of the castrate mice under the influence of androgen pellets with that of normal mice of the same strain. Such comparisons are made in Table 6. Although the first encounters during which the castrate mice with implanted male hormone were aggressive actually occurred during the second group of six rounds, from the point of view of past experience in aggressive behavior, these encounters are comparable to the first six rounds of encounters experienced by normal mice.

The castrate C57 black mice exhibited more tail-rattling, parrying, mincing, attacking, and fighting during the six rounds of encounters when pellets of testosterone propionate were present than did normal C57 black mice during the first or second group of six rounds of encounters.

The castrate albino mice with testosterone propionate pellets exhibited more of typically aggressive behavior than did the normal albinos in the first six rounds of encounters. During the second six rounds of encounters, however, these normal mice displayed slightly more mincing, attacking, and fighting than did the castrate mice possessing implanted male hormone.

In both strains of mice an increase in one or more types of aggressive activity occurred in the rounds immediately following the initial aggressiveness induced by the androgen. A peak of aggressive behavior was observed in the 2d, 3d, or 4th rounds, following the implantation of male hormone in each of the seven groups of castrates so treated; and this rise was followed, in most cases, by a decrease in the amount of all types of aggressiveness displayed (Figs. 5 and 6). The decrease began in the 9th or 10th round among the albinos and in the 11th round in two groups of black mice. After this drop in total aggressive activity, a slight rise in one or more types of activity took place in five of the seven groups of treated castrates.

The above trends in aggressiveness may be compared with similar peaks and decreases of activity which may occur in groups of normal C57 black and albino mice. Black Set VII (Fig. 1, *a*) and albino Set IX (Fig. 2, *a*) show sharp increases in aggressive behavior following initial encounters, with subsequent decreases in activity. Although the mice in albino Set V were slow to begin aggressive activity, they also showed similar increases and decreases in aggression.

TABLE 6

AVERAGE AGGRESSIVE ACTIVITY OF GROUPS OF FOUR MICE DURING PERIODS OF SIX ROUNDS
(Each category is based on totals from two groups of mice)

Group	Tail Rattle	Parry	Mince	Attack	Fight
Albino ♂ with T.P.	227.0	0.5	23.5	98.0	65.0
Albino normals (1st 6 rounds)	132.0	0	12.0	53.5	48.5
Albino normals (2d 6 rounds)	222.0	1.0	26.0	127.0	76.5
Black ♂ with T.P.	74.5	13.5	62.0	154.0	108.0
Black normals (1st 6 rounds)	27.5	10.5	11.0	146.5	94.0
Black normals (2d 6 rounds)	48.0	7.5	37.5	120.5	52.5

AGGRESSIVE ACTIVITY OF ANDROGEN-IMPLANTED CASTRATE MICE IN GROUPS OF THREE AND IN GROUPS OF FOUR

There seems to be a difference between the amount of aggressive activity displayed by individual mice in groups of three C57 black castrate mice with im-

planted pellets of testosterone propionate and that exhibited by similar mice in groups of four. Since data are available on only two groups of mice in each of these categories, statistical treatment is not possible. However, as indicated in Figure 7, any two mice which were members of groups of four mice performed more tail-rattling, attacking, and fighting in a single encounter during each of six rounds than did mice which were members of groups of three. At present no ex-

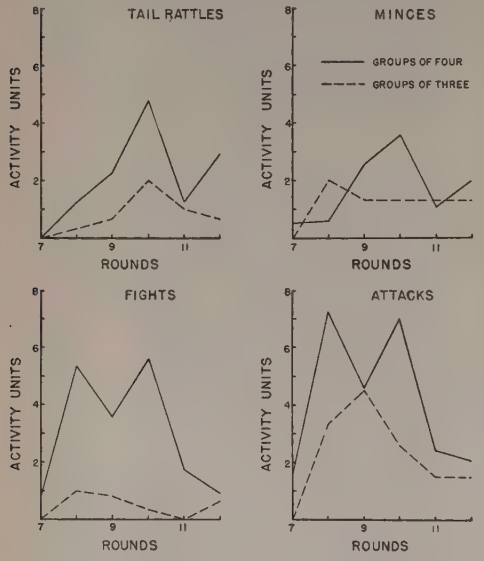

FIG. 7.—Comparison of the average amount of aggressive activity per encounter per round in androgen-implanted castrate C57 black male mice in groups of three with that in groups of four. Groups of three, Sets II, IX; groups of four, Sets I, V.

planation can be offered to account for the stimulating effect which an additional encounter apparently had on the total aggressiveness shown in other encounters.

EFFECT OF CASTRATION AND IMPLANTATION OF TESTOSTERONE PROPIONATE ON THE WEIGHTS OF SEMINAL VESICLES AND PROSTATE GLANDS

It has been known for many years that the size and function of the seminal vesicles and prostate glands are controlled by testicular hormone and that these glands are reduced in size in animals that have been castrated for some time (reviewed in Moore, 1939). It has been demonstrated that the seminal vesicles and prostates of the mouse atrophy rapidly after castration. Martins and Rocha E Silva (1929) have reported that within 10–13 days following gonadectomy there is a marked reduction in the size of the seminal vesicles. However, since they found that the weight reduction was variable in mice of over 17–18 gm., they utilized length-times-breadth measurements of these glands as an indication of the amount of androgen present. Deanesly and Parkes (1933) have found that within 7 days after postpubertal castration in mice, about half the combined weight of the seminal vesicles and anterior prostatic lobes is lost. By 3 weeks after castration, the atrophy is considerably advanced, and further slight decreases in weight follow up to 7 weeks. A nearly constant level of less than 10 per cent of the original glandular weight is gradually attained. These authors disagree with Martins and Rocha E Silva (1929), believing that there is less variation in weight in the glands of mice over 24 gm. than in those of smaller mice.

Confirmation of the dependence of seminal vesicle and prostate size on male hormone has been attained in the present study. Since it has been shown that the aggressive behavior of mice also is affected by the presence of testicular hormone, it is to be anticipated that a correlation may be found between the size of these male accessory glands and the aggressive activity of these animals.

The mice of C57 black Sets IX and V and albino Sets I and VI, which contained androgen pellets during the 6th through the 12th rounds of encounters, were killed, and the pellets were removed

immediately after the end of the 12th round. Pellets of male hormone also were removed from the members of C57 black Sets I and II, and albino Set II at the end of the 12th round after these mice had been carrying the pellets for six rounds, a period of 3 weeks. However, the members of these three sets experienced a third set of six rounds of enof the same strain was 7.0 mg. In albino mice the average weight of the glands of six normal mice was 195.71 mg., and 6.18 mg. for the glands of eight castrates. There was no significant difference between the average weight of the seminal vesicles of normal mice of both strains and that of the castrate mice of these strains in which the pellets of androgen

TABLE 7

EFFECT OF CASTRATION, IMPLANTATION, AND REMOVAL OF PELLETS OF TESTOSTERONE PROPIONATE ON THE WEIGHT OF SEMINAL VESICLES AND PROSTATE GLANDS OF C57 BLACK AND BAGG ALBINO MICE

DIFFERENCE BETWEEN THE WEIGHT OF ORGANS OF:	*P*-VALUES AND AVERAGE WEIGHT OF GLANDS*			
	C57 Black Mice		Albino Mice	
	Seminal Vesicles	Prostates	Seminal Vesicles	Prostates
Castrates	<0.0002†	<0.0002†	<0.0002†	<0.0002†
Normals	7.0 264.0	1.9 17.8	6.2 195.7	2.95 20.7
Androgen out at autopsy	0.058 153.3	>0.5 15.5	>0.5 188.8	<0.0002‡ 25.4
Normals	264.0	17.8	195.7	20.7
Androgen out at autopsy	0.0095† 153.3	0.0075† 15.5	<0.0002† 188.8	<0.0002† 25.4
Castrates	7.0	1.9	6.2	2.95
Androgen out at autopsy	>0.5 153.3	0.0214 15.5	<0.0002 188.8	<0.0002 25.4
Androgen out 21–22 days before autopsy	129.0	4.2	15.8	4.03
Androgen out 21–22 days before autopsy	0.01† 129.0	0.0030† 4.2	<0.0002† 15.8	0.12 4.03
Castrates	7.0	1.9	6.2	2.95

* *P*-values are given in the first line. Average weights of glands in milligrams are given in the second and third lines.
† Larger than castrates. ‡ Larger than normals.

counters and were killed 21–22 days after removal of the pellets (Table 3).

Seminal vesicles.—The seminal vesicles of the castrate C57 black and albino mice weighed significantly less than these glands in normal mice of both strains, i.e., $P < 0.0002$ in both cases (Table 7). The average weight of the seminal vesicles in eleven normal C57 blacks was 264.0 mg.; that of seven castrate mice were removed on the day of autopsy. Since the accessory glands of the castrate C57 black and albino mice from which pellets of male hormone were removed at autopsy were as large as, or larger than, the seminal vesicles of normal mice, it is not surprising that these glands were also significantly larger than those of castrate mice of the same strain.

The seminal vesicles of castrate C57

black mice whose pellets were removed on the day of autopsy averaged 153.3 mg.; those of castrate black mice from which the pellets were removed 21–22 days before autopsy averaged 129.0 mg. There is no significant difference between these weights, indicating that the seminal vesicles of the black mice did not regress in weight rapidly after the withdrawal of male hormone. The C57 black mice from which androgen pellets were removed 22 days before autopsy averaged 80.0 days of age when castrated. Those from which the pellets were removed on the day of autopsy averaged 42.4 days of age at castration. According to Martins and Rocha E Silva (1929), in older animals the atrophy is irregular and sometimes retarded; and Kochakian (1941) states that animals which are older at time of castration exhibit a greater response to comparable amounts of androgen. The difference between the seminal vesicles of albino mice in these two categories is highly significant ($P < 0.0002$). These facts may explain the "apparent" slow regression in weight of the seminal vesicles in the former group after pellet removal. There was a difference of only 13 days between the ages of these two groups of albinos. Thus, 21–22 days after removal of pellets of male hormone, the seminal vesicles of the albino castrates had significantly decreased in size.

Since it has already been shown that 21–22 days after removal of androgen pellets the seminal vesicles of the C57 mice are approximately the same size as those of the mice which had the pellets removed on the day of autopsy and since the difference between the weights of the seminal vesicles of the latter mice and normals is insignificant, it is to be expected that the weights of these glands in mice whose pellets had been removed 21–22 days before autopsy would be significantly greater than those of the seminal vesicles of castrate C57 black mice, e.g., P is found to be 0.01.

Prostate glands.—The prostate glands of castrate mice of both strains weighed significantly less than these glands did in comparable normal mice. The average weight of the prostate glands of twelve normal black mice and seven castrate black mice was 17.8 and 1.85 mg., respectively. The prostates of seven normal albino mice averaged 20.7 mg. as compared with 2.95 mg. for eight castrate albino mice.

There was no significant difference between the average weight of the prostate glands of normal C57 black mice and that of castrate black mice from which the pellets of male hormone had been removed at autopsy. However, the difference between the prostate gland weights of albino mice in these two categories is significant; the normal glands are much larger.

The mice of both strains from which the pellets of testosterone propionate had been removed on the day of autopsy possessed prostate glands which were significantly larger than were these glands in castrate mice of the same strain.

The prostate glands of six C57 black castrates which had had the pellets removed on the day of autopsy averaged 15.5 mg., in contrast with an average of 4.2 mg. for the prostate glands of five C57 black castrates which had been deprived of pellets for 21–22 days at autopsy. This difference in weight is significant: $P = 0.021$. Thus the prostate glands of the castrate C57 black mice regress more rapidly after the withdrawal of male hormone than do the seminal vesicles of these mice. The difference between the average weight of the prostate glands of the albino mice in these two categories is also significant. Thus, 21–22 days after removal of pellets of male hormone, the prostate glands of the albino

castrates have also decreased significantly in size.

The prostates of the C57 castrate mice deprived of androgen for 21–22 days before autopsy were also significantly larger than those of castrates, indicating that, although they weighed significantly less than those of C57 mice whose pellets were removed at autopsy, they had not yet regressed to the castrate level. However, 21–22 days after removal of pellets of male hormone, the average weights of these glands in castrate albino mice had reached a size which was not significantly larger than that of castrate mice which had never had pellets implanted.

The *P*-values[4] listed above have been calculated on the data from small numbers of mice, since only data from those mice from which both seminal vesicles or both prostate glands had been removed intact were used. In the mice which had been castrated for some time it was difficult to find and completely remove the very small glands.

The amount of aggressive behavior displayed by normal and castrate mice and by castrate mice from which androgen pellets had been removed at autopsy or 21–22 days before autopsy is compared in Table 8 with the size of the seminal vesicles and prostate glands of these animals. It is evident that the amount of aggression displayed is fairly closely correlated with the size of these male accessory glands. When the glands are approximately the same weight in two

TABLE 8

CORRELATION OF THE EFFECTS OF CASTRATION AND IMPLANTATION OF TESTOSTERONE PROPIONATE ON THE SIZE OF SEMINAL VESICLES AND PROSTATE GLANDS OF C57 BLACK AND BAGG ALBINO MICE WITH THE AMOUNT OF AGGRESSIVE BEHAVIOR DISPLAYED BY THESE MICE

Groups of Mice	Strain	Weight of Glands	Amount of Aggressive Behavior
Castrates with androgen pellets removed at autopsy	Blacks and albinos	Same as normals*	Same as normals
	Blacks and albinos	Heavier than castrates*	Greater than castrates
	Blacks	Seminal vesicles same as those in mice with androgen removed 21–22 days before autopsy Prostates heavier than those in mice with androgen removed 21–22 days before autopsy	With 1 exception, greater than those mice with androgen removed 21–22 days before autopsy
	Albinos	Heavier than those in mice with androgen removed 21–22 days before autopsy*	Greater than those mice with androgen removed 21–22 days before autopsy
Normal mice	Blacks and albinos	Heavier than castrates*	Greater than castrates
Castrates with androgen pellets removed 21–22 days prior to autopsy	Blacks	Heavier than castrates*	Greater than castrates (1 exception)
	Albinos	Seminal vesicles heavier than castrates Prostates same as castrates	Same as castrates

* Both seminal vesicles and prostates.

[4] $t = \dfrac{\bar{x}}{\sqrt{\dfrac{\Sigma x^2 - \bar{x}\Sigma x}{n(n-1)}}}$; degrees of freedom $= n-1$.

groups of mice, the behavior is also approximately the same. Or, if the glands are larger in one group than in the other, the former displays more aggression than the latter. This correlation results, of course, from the fact that both the size of the accessory glands and the amount of aggressive behavior displayed are affected by the amount of male hormone which is present.

EFFECTS OF PELLETS OF DEXTROSE

No change occurred in the behavior of the members of two sets of albino castrates, III and VIII, or in that of the members of two sets of C57 black castrates, IV and VIII, when pellets of dextrose were implanted after each set had had six rounds of encounters. Table 3 indicates that these mice did not display a single aggressive act before the pellets of dextrose were introduced and that absolutely no aggressiveness was apparent in any of the 126 encounters in the second group of six rounds after the pellets had been implanted. Albino Set III was permitted to experience a third group of six rounds of encounters, and all the mice continued to be unaggressive.

DISCUSSION

The present study on aggressiveness has been concerned with normal behavior directed toward other animals of the same species and strain. Under these conditions the males of both the C57 black and the Bagg albino strains exhibit aggressive behavior that is qualitatively similar. There is a general trend for more attacking and fighting on the part of the black mice, and the albinos rattle their tails significantly more than do the C57 blacks. The data previously reported on aggression in these strains have dealt with aggression between strains, primarily with ability to initiate or win encounters and not with the aggressive behavior pattern within a given strain.

Under the particular experimental conditions which were used by Ginsburg and Allee (1942) the C57 blacks were superior, the C3H agoutis were intermediate, and the albinos were least effective in winning battles. From observations based on prefighting and fighting behavior of these strains, Scott (1942) rated the C57 blacks as being pacific under certain conditions, the C3H as exhibiting a moderate degree of activity and a tendency to avoid close contacts, and the albinos as possessing moderate activity and aggressiveness. Results of experiments which present some possible explanations for the difference between the results obtained by Ginsburg and Allee and those reported by Scott will be published later.

It has been shown that the amount of any of the components of the aggressive behavior pattern exhibited in a single 5-minute encounter or in a round of such encounters may differ markedly from the amount displayed in another similar encounter or round. These fluctuations in amount of particular types of behavior in groups of normal males may result from several factors. One of these is concerned with the order in which the mice happen to meet on any given day. If the encounters that an aggressive mouse has at the beginning of a round are with fairly submissive mice, the former may rattle his tail vigorously, mince, and attack repeatedly in subsequent encounters. If, however, the first encounter happens to be between two very aggressive mice, they may attack and fight each other so vigorously that each becomes conditioned to show little aggression in subsequent encounters on that particular day.

Conditioning which extends over a period of time longer than a day may

also influence the amount of aggressive behavior which is displayed. If a mouse has been severely beaten in a series of encounters, he may remain submissive or inactive for a week or more. Recorded aggressive activity may be greatly reduced in a group in which only one mouse is very actively aggressive, since, if his opponents submit at the first sign of aggressive behavior, encounters automatically end. If, on the other hand, two moderately aggressive mice are paired, a single encounter may continue for 5 minutes, with first one mouse attacking or rattling his tail or otherwise exhibiting aggressive behavior and then the other mouse showing signs of taking the initiative. In such an encounter a large amount of aggressive activity would be recorded, with neither mouse necessarily losing or winning the encounter.

Seward (1945*b*) describes behavior of the rat in which decreases and increases in aggressive activity occur which are somewhat similar to those which appear so clearly in various groups of normal and androgen-implanted mice of both strains. He finds a general decline in fighting in the course of a series of contacts, but the rats used recovered their pugnacity in the intervals between series. Apparently, the large amount of aggressive behavior displayed by the mice during the first several rounds of encounters is sufficient to condition them gradually to show less aggression as a group. Subsequent encounters with unaggressive individuals aid in restoring former aggressiveness.

In a later study Seward (1946) reports similar conclusions for behavior of rats, stating:

> The day after a fight the average loser made fewer aggressions or advances than before against the winner and against another rat. Exposure to an inoffensive rat completely restored the average loser's aggressions or advances against that rat, against the winner, and against another animal. One session was sometimes enough, but even after a week of daily sessions the restored aggressiveness collapsed readily [p. 75].

Aggressive behavior in rats has been the subject of various investigations, and in several of these, as in the present experiments, the aggression has been directed against other members of the same hereditary strain. It was found by Davis (1933) that isolated rats which were fed once every 24 hours did not act in an aggressive fashion when strange rats were introduced. If, however, the rats were fed only once every 48 hours, the isolated rats would allow the introduced rats to eat and then would become aggressive, pushing and shoving the strange rat. These results are of interest, in view of the fact that Ginsburg and Allee (1942) found that a 36-hour period of starvation made no difference in the aggressiveness of their mice; they observed only one fight over food, and that did not occur during or after a period of starvation.

A frustrating food situation has been used by Billingslea (1941) to provoke aggressiveness in female rats. When female rats, regularly caged in groups of three, were tested in a food situation that allowed only one rat to eat at a time, "emotional" rats tended to be less aggressive than those from a nonemotional strain. Aggression was measured by recording the number of fights participated in on 6 possible days.

Davis (1933) devised a scale for rating aggressiveness directed against other rats. Hall and Klein (1942) used Davis' scale and, in addition, developed a modification that they believed to be more discriminating. They report that rats selectively bred for fearlessness in a strange situation were more aggressive than those bred for timidity.

Much of the research in this field which has been reported for rodents has dealt either with aggressive behavior di-

rected against the investigator or with tameness and wildness, where the degree of wildness has been indicated by speed in going through a runway or maze. Few data have been given which correlate such "aggressiveness" or "wildness" with aggressive behavior of the type under consideration here. However, these studies do have a bearing on the present problem, since they indicate that factors such as "wildness," "savageness," and "tameness" have a hereditary basis in several strains of rats and mice, as do components of the aggressive behavior pattern which have been the subject of this investigation.

Wildness and tameness, as measured by the length of time required for a given mouse to traverse the length of a 22-foot runway, appear to be inherited characteristics (Dawson, 1932). Wild mice bred from individuals caught in fields ran the distance in a much shorter time than did three strains of tame laboratory mice. The genes responsible for tameness apparently are almost completely recessive to those producing wildness.

Coburn (1922), using a rating scale originally devised by Yerkes (1913) to measure savageness, wildness, and timidity in rats, tested wild mice and tame mice for savageness and wildness. Tests of mice from matings between wild and tame stocks were also made. The aggressive behavior was not directed against other mice but against the investigator. Yerkes' rating scale (1913) for savageness included (1) biting, (2) exposing or gnashing teeth, (3) jumping at hand or forceps, and (4) squeaking. Wildness involved (1) attempts to hide from view in cage or hand, (2) random and excited running about in the cage or excited attempts to escape from the hand or the forceps, (3) squeaking, (4) urination and defecation. Although in some instances Coburn found almost complete dominance of wildness and savageness factors over factors for tameness, the results do not indicate any simple genetic principles of dominance and recessiveness. A certain amount of conditioning occurred during these experiments, since there is a decrease in the grades of wildness and savageness in successive tests. This decrease was undoubtedly brought about through handling and daily presence of the experimenter during routine care of the colony.

Savageness and wildness were observed by Yerkes (1913), Utsurikawa (1917), and Stone (1932) to occur coincidentally in rats. In each case the savageness and wildness were directed against the experimenter. Yerkes' results in the F_1 generation indicate that wildness and savageness are largely dominant over tameness. However, in the F_2 generation there was a decrease in savageness and wildness that cannot be explained on these grounds. Handling and unwitting selection of the F_1 generation for breeding may account for the results.

Inbred rats from the Wistar stock were found to differ from outbred stocks in exhibiting twice as much savageness as the outbred group. In this case, savageness was tested by recording the attempts to bite a copper wire thrust into the cage (Utsurikawa, 1917). Stone (1932), using an 11-point rating scale for wildness and savageness, found differences in wildness and savageness among wild rats, half-breeds, quarter-breeds, and tame rats, and he concluded that these differences are probably hereditary in nature. Information concerning other behavior studies may be found in a very extensive review of the literature on temperament in rats and mice which has been made by Hall (1941).

Androgens have been found to stimulate aggression in males and females of

many vertebrates. Since Collias (1944) has recently reviewed the literature in this field, only data pertaining to the effects of male hormone on aggressive behavior of males will be mentioned here.

Castrate male lizards, *Anolis carolinensis*, have been observed to fight more actively than controls after being injected with testosterone propionate (Noble and Greenberg, 1941). There is a large amount of evidence indicating that androgens increase aggressiveness in male birds. Testosterone propionate caused defense of territory in month-old male chicks of the black-crowned night heron (Noble and Wurm, 1940); and several investigators have been able to induce cocklike fighting in male chicks injected with androgens (see Noble and Zitrin, 1942). Three male valley quail, *Lophortyx californica vallicola*, which had been implanted with pellets of testosterone during the winter, became pugnacious toward other males and aggressive toward females within 45 hours after implantation. However, the position of these males in the social hierarchy did not change (Emlen and Lorenz, 1942). Male herring gulls which had been injected with testosterone propionate as embryos were, as juvenales the most aggressive birds in a colony maintained by Boss (1943) and dominated all the birds with which they came in contact.

Although Kochakian (1941) does not define aggressive behavior, he reports that castrate Rockland mice were aggressive after pellets of testosterone propionate had been implanted and that normal mice of this strain showed the same disposition. It is of interest to note that the Buffalo-Marsh mice used by Kochakian lacked these aggressive tendencies. After receiving methyl testosterone injections daily, the dominance status of a prepubertal castrate male chimpanzee was enhanced in a food-getting situation (Clark and Birch, 1945).

Unpublished data on a preliminary investigation by Allee and Warne indicate that when pellets of testosterone propionate were implanted in one Bagg albino and in four normal C57 black male mice, no unusual change in aggressive activity occurred. Two of these mice showed no aggressiveness, and the activity of the other three was within the normal range of variability of aggressiveness. These data are not out of line with those in the papers mentioned above, since in the other cases the androgen therapy was effective in inducing aggressiveness out-of-season, in castrates, or in immature animals.

In the present study one attack which was begun but not completed was the only sign of aggressive behavior which was noted on the first day after implantation of testosterone propionate. Two groups failed to exhibit aggressiveness on the second day following implantation. Aggression was exhibited within 4–6 days after implantation of testosterone propionate in seven previously unaggressive groups of C57 black and Bagg albino castrates. From the data of Kochakian (1941) it can be seen that 5 days after implantation of a 22-mg. pellet of testosterone propionate the combined weight of the seminal vesicles and prostate glands was less than one-third that of normal mice; 11 days after implantation of an 11-mg. pellet the weight was slightly less than two-thirds of the normal weight; and 13 days after the implantation of a 22-mg. pellet the glands had not yet attained full size. Since it has already been shown that the rate of absorption of testosterone propionate from pellets implanted in the present study is slightly greater than the rate of Kochakian's 11-mg. pellets and less than that of the 22-mg. pellets, it can be stated

that, in the present study, the mice began to display aggressive behavior at a time when the amount of hormone absorbed was not sufficient to stimulate the accessory glands to attain normal size.

Encounters occurred either 3 or 4 days after the removal of the androgen pellets. At this time and in the encounters which were staged during the next 3 weeks, the majority of the treated castrates did not display any aggression. Thus seven of the ten mice which experienced encounters after the removal of the androgen pellets failed to show aggressiveness; two displayed only 3 attacks, 4 tail rattles, and 1 mince in a total of twelve rounds; and the aggressiveness of the third mouse undoubtedly can be explained by incomplete removal of the androgen pellet.

Since the present experiments were not performed primarily to study the effects of castration and androgen therapy on the size of the accessory sex glands, data are not available on the weight of these glands in the days immediately following withdrawal of male hormone. However, other investigators have noted glandular changes as a result of the rapid disappearance of male hormone following castration. Deanesly and Parkes (1933) state that the seminal vesicles and the anterior prostatic lobe of mice lose about half their weight in 7 days; and Moore, Price, and Gallagher (1930) report changes in the middle and posterior lobes of the rat prostate, 4 days after castration. It is probable that the weights of accessory glands in the present experiment would approximate those of Deanesly and Parkes (1933). Moore, Price, and Gallagher (1930) also state that castration effects appear within the same time after cessation of injection of extracts of bull testes as after testes removal. In the present study the earliest encounters were staged 25 days after castration, and, at this time, the mice did not act aggressively. Experiments are now in progress to investigate the behavior of mice in encounters which occur immediately after castration.

There is evidence that aggressiveness by males may not be entirely dependent on androgens produced by the male gonad. Male swordtail fish will maintain position in their social orders from 1 to $6\frac{1}{2}$ months after castration (Noble and Borne, 1940). Male lizards which had been castrated for $1–4\frac{1}{2}$ months have been observed to display aggressive behavior, consisting of dewlap extension, flattening of sides, and fierce fighting with teeth—behavior precisely like that of normal males (Evans, 1936). Although gonadectomy in cocks results in a decrease in aggressiveness, fighting and aggressive behavior do occur in capons (Davis and Domm, 1943).

In some animals, mating behavior also persists for varying lengths of time after castration. Ability of male rats to copulate after castration at 90 days of age has been shown by Stone (1927) to disappear slowly. In his study, copulatory ability was retained for more than 7 months by two of forty-five gonadectomized males; by the end of the 8th month none of the rats displayed mating behavior. Moore (1939) concludes from previously unpublished data on rats and guinea pigs that copulatory ability may be expressed for long periods after castration, and it has been reported by Clark (1945) that the development of sexual behavior in the prepubertally castrated chimpanzee is similar to that in the normal animal.

The results of the present investigation on castration differ markedly from those of Uhrich (1938), who found that castration did not inhibit fighting in all mice. It is true that the experimental conditions of this study are not exactly

comparable with those used by Uhrich, since the mice in the present investigation were isolated except during encounters, which were staged on 2 days of each week, and thus could not form a true social organization such as Uhrich described for groups of caged mice. However, since Ginsburg and Allee (1942) indicate that mice kept in isolation are much more prone to exhibit aggressive activity when brought together for staged encounters than are mice which are constantly caged together, it might be expected that the mice of this study would exhibit more aggression than those used by Uhrich.

In attempting to account for the difference between the present results and those of Uhrich (1938), it has been necessary to analyze Uhrich's data in some detail. It is difficult to determine the exact experimental conditions experienced by Uhrich's mice, since the number of animals in each "group" is not given and the number of mice in each group that were castrates, unilateral castrates, and normals is not indicated.

Since Uhrich watched as many as thirty groups at once, it must have been impossible to record all the various aspects of aggressive behavior which appeared. It was not stated whether normal aspects of the aggressive behavior pattern other than fighting (e.g., tail-rattling, mincing, attacking, and parrying) were reduced in amount or were absent. In fact, fighting, identified as a mere snap or dart, on the one hand, or very severe biting, on the other, was the only type of aggression mentioned. "Attacking," as it is used in the present study, may possibly be included in his term "fighting."

Uhrich castrated some individuals in each of four groups before sexual maturity. Of these, two groups were composed solely of bilaterally castrated animals; two groups contained one or more males which retained at least one gonad. It is stated that fighting rarely occurred in three of these groups and that in one a unilateral castrate regularly routed another unilateral castrate. The unilateral castrates may be considered essentially normal, since Moore (1939) reports that, when one testis is removed, the remaining testis secretes a quantity of hormone normal for the former pair of testes. In two of the groups castrated before maturity, a mouse fought as late as 100 days after gonadectomy. From the data given it is impossible to determine, in the first case, which three of the four groups are meant and whether the two groups of animals in the latter case were composed completely of bilateral castrates.

In four additional groups which included some unilateral and some bilateral castrates, castration was performed after sexual maturity. In three of these, a bilateral castrate was exclusively dominant for some time. Castrates are stated to have fought as late as 156, 168, 206, 247, 255, and 292 days after castration. The accessory sexual organs of a male mouse which fought on the 144th day after castration were found to be in the typical castrate condition on that day, indicating that castration had been complete.

The difference between the results obtained by Uhrich and those presented here cannot be explained by assuming that, in the present study, a longer period of time had elapsed between castration and opportunity for aggression, since one set of mice was paired as early as 25 days after castration, the encounters of five sets were begun 40 days or less after gonadectomy, and all thirteen sets had begun encounters by 140 days after castration. Uhrich recorded fighting by six complete castrates at much later dates after castration.

The mice used in these tests cannot be considered to be too young or too old to

behave aggressively, since mice of comparable ages were actively aggressive. In Uhrich's colony, the minimum age at which the first fight was recorded in young mice was 30 days, and the average age of 40 groups of mice at the time of the first combat was 50 days. These figures may not be typical for the C57 black and Bagg albino males. However, it is of interest to note that, of the 13 sets of mice castrated, 4 sets were gonadectomized prior to 30 days, and 5 sets prior to 50 days of age. Thus, 30 of the 48 mice were not castrated until after 50 days of age, when aggressive behavior might normally have been expected to appear.

It is evident that there is a need for accurate definition of the stimuli which activate normal patterns of aggression in mice. Aggressive behavior has been analyzed for *Anolis carolinensis* in terms of a chain of reflexes (Evans, 1936); and overlapping stimulus-response components have been reported for the robin's territorial-defense reactions (Lack, 1939). In a study of the stimuli necessary for mating in rats, Beach (1942) reported that, for the majority of male rats lacking sexual experience, the receptive female is the only stimulus adequate to induce initial mating reactions. There are a few very excitable males, however, which will attempt to mate with animals other than the receptive female, and a small proportion of inexperienced males are not aroused to copulate even with a highly receptive female. In the same study Beach demonstrated that in sexually inexperienced copulators elimination of more than one of three sensory receptors (vision, olfaction, and cutaneous sensitivity in the snout and lips) was sufficient to prevent copulation in rats but that all sexually experienced males continued to copulate after any two of the three sensory receptors were destroyed. Tinbergen (1942) has reviewed additional studies concerned with releasive mechanisms in animals.

To the writer's knowledge, no comprehensive studies of this type have been made of the stimuli which are necessary to activate aggressive behavior in rodents. Since castrates did fight under the experimental conditions used by Uhrich (1938) and did not exhibit aggressiveness in the present study, it becomes of interest to attempt to determine the stimulus (or stimuli) adequate to elicit such behavior in mice.

This investigation has indicated that, without doubt, the castrate male is not an adequate stimulus to induce aggression among castrates. There is also evidence which suggests that a "normal-acting" male is not an adequate stimulus to induce aggression in gonadectomized males, since one castrate in C57 black Sets I and IX continued to act aggressively after removal of the androgen pellet and the five castrates which were members of these two groups did not exhibit aggressive behavior.

In making an analysis of Uhrich's data, we found that the fights by castrates which were specifically mentioned occurred when strange normal males were introduced or, in one instance, when a unilateral castrate was introduced with other members of his group. From the data given it cannot be ascertained whether these are the only conditions under which fighting by castrates occurred. It seems possible that castrates or normal animals which are members of a group continually caged together do not constitute adequate stimuli to elicit aggression in castrate males. At this time it is difficult to state what features of a newly introduced mouse are sufficient to identify a given individual as a stranger or what the sensory receptors are which enable identification to be made.

Personal observations support the

view that individual recognition among mice probably is very slight if not nonexistent. Uhrich (1938) believes that mice can clearly distinguish between an old member of a group and a newly introduced one but states: ". . . . it seems doubtful whether one mouse always distinguishes between other mice in the cage. Rather, it sometimes appears as though the subordinates do not recognize the dominant but merely flee from any mouse that happens to attack them or that assumes an aggressive attitude" (p. 402). Ginsburg and Allee (1942, p. 504) believe that it may be possible that "mice respond to deportment rather than to individuality." Evidence that vision is not essential in the reaction of albino mice to one another is given by Uhrich (1938). He found that mice maintained positions in their dominance hierarchy for some time after blinding and reacted to strange males in a manner similar to that of normal males.

Tinbergen (1942) states that internal factors which drive an animal to perform certain special actions may be of three different kinds: hormones, proprioceptive stimuli, and springs of impulses from within the central nervous system itself. Little is known about the effects of stimuli belonging to the last two categories on aggression in mice, but the possibility of their operation should not be overlooked.

SUMMARY

1. The aggressive behavior pattern of normal male C57 black mice is qualitatively similar to that of normal male Bagg albino mice.

2. Normal C57 black mice display more attacking and exhibit a general trend to fight more frequently than do the albino mice. The albino mice rattle their tails a greater number of times in each round than do the black mice.

3. When the ratio of

$$\frac{\text{Attacks}}{\text{Tail rattles} + \text{attacks}}$$

in both strains is compared, the difference between the two strains is highly significant; $P < 0.0001$ ($t = 11+$).

4. Fluctuations occur in the frequency with which the components of the aggressive behavior pattern are displayed by normal mice of both strains. Such changes may result from the initial aggressiveness of the group as a whole, conditioning the mice to show less aggression, and subsequent encounters with nonaggressive mice restoring the ability of mice to display aggressive behavior.

5. Similar variations in aggressiveness occur in androgen-implanted castrates.

6. As general aggressiveness increases, there is a decrease in grooming and vice versa.

7. Castration of C57 black and Bagg albino male mice as immature animals or as adults results in the failure of these mice to display aggressive behavior, regardless of age at isolation when a period of 25 or more days elapses between castration and initial encounters.

8. Testosterone propionate pellets subcutaneously implanted will induce castrate mice of both strains to display aggressive behavior characteristic in quality and quantity of normal male mice of comparable strain.

9. Removal of androgen pellets from castrates results in an almost immediate cessation of aggressiveness in the majority of mice.

10. After androgen therapy has begun, additional encounters may stimulate castrate mice to exhibit more aggressiveness within a single encounter, since any two mice which were members of sets of four mice displayed more tail-rattling, attack-

ing, and fighting in a given encounter than did mice which were members of sets of three.

11. The amount of aggressive behavior displayed is positively correlated with the size of the seminal vesicles and prostate glands, since both are affected by amount of androgen present.

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